Good Practice

Guide 80

Refurbishment of high rise dwellings – A strategic guide for local authority managers

"Energy efficient dwellings offer lower management and maintenance costs"

BEST PRACTICE PROGRAMME

Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

ENERGY EFFICIENT DWELLINGS

CAN BENEFIT:

- **YOUR AUTHORITY**
  By being easier to maintain and easier to let, with less risk of litigation from dissatisfied tenants.
- **YOUR TENANTS**
  By being more comfortable to live in and having lower fuel costs and a healthier environment.
- **THE NEIGHBOURHOOD**
  By upgrading the appearance of high rise blocks.
- **THE COUNTRY**
  By reducing the demand for fuel and consequently helping to make more efficient use of non-renewable fossil fuels.
- **THE ENVIRONMENT**
  By reducing pollution from (CO_2) emissions and acid rain associated with energy usage.

WHY SAVE ENERGY?

FOR THE TENANT, ENERGY EFFICIENT DWELLINGS:

- provide 'affordable warmth' for low income households
- achieve temperature levels such as 21°C in the living areas and 18°C in the rest of the house during cold spells
- are more comfortable, cheaper and easier to heat
- can stay warmer longer or can heat up quicker
- have less draughts particularly from windows and doors
- have better ventilation systems.

FOR THE LANDLORDS, ENERGY EFFICIENT DWELLINGS:

- have lower heating bills leaving the tenant more able to pay the rent
- reduce condensation risks
- provide a healthier environment for tenants and reduces any chance of litigation
- are more popular, have less voids and hence higher rent revenues
- reduce maintenance costs by keeping the building structure in better condition
- can improve the appearance of estates with external insulation measures thereby increasing asset values
- can cost up to 15% more than ordinary refurbishment but savings can be made through installing a cheaper heating system and from future maintenance costs.

WHAT TO DO ABOUT ENERGY SAVING

Many local authorities in large towns and cities responded to the demand for dwellings in the 1960s and 70s by building blocks of flats.

High-rise blocks – usually defined as blocks of six or more floors served by lifts – commonly take the form of:

- Point blocks – internal access to four or six flats per floor
- Slab blocks – internal access to eight or more flats per floor. External gallery access at every second floor to eight or more maisonettes.

There are many variations of these basic types. Several construction types are described briefly on the following pages together with energy efficient measures that are available.

COLUMN AND BEAM

- In situ concrete column and beam frame.
- In situ concrete floor slab.
- Brick cavity external walls.
- Metal or timber windows.
- Various heating systems but commonly underfloor electric.

BOX FRAME

- In situ concrete box-frame (or 'egg-crate').
- Brick cavity or precast concrete panel infill external walls.
- Flat roof.
- Metal or timber windows.
- Various heating systems but commonly underfloor electric.

LARGE PANEL SYSTEMS (LPS)

- Precast concrete prefabricated room sized wall and floor panels.
- External wall panels smooth textured or exposed aggregate finishes.
- Flat roofs.
- Metal or timber windows – some may be cast into wall panels.
- Various heating systems – commonly gas or electric warm air or old storage heaters.

NO-FINES

- In situ no-fines solid concrete walls.
- External brick skin or rendered.
- In situ concrete floors.
- Flat roofs.
- Metal or timber windows.
- Various heating systems but commonly underfloor electric or old storage heaters.

CONSTRUCTION CHARACTERISTICS

All construction types may exhibit the following characteristics.

- Poor thermal performance when compared with current regulations.
- Underfloor electric heating too expensive for tenants to run and inadequate.
- Internal bathrooms with poorly maintained extract ventilation systems.
- High incidence of condensation and mould growth.
- Flat roofs covered with 3-layer bituminous felt or asphalt. Leaks temporarily cured by patch repair.
- Poor roof insulation.
- Concrete or brick spalling. Reinforcement and wall ties corroding.
- Windows single glazed and not draught-stripped. Twisted opening sashes and very high exposure giving rise to a high level of complaints about leaking and draughty windows.
- Excessive heat loss from very large windows to balconies.
- Balconies and access galleries frequently a source of 'thermal bridging' where floor and/or walls are continuous from inside the dwelling to outside.

RELEVANT ENERGY EFFICIENCY MEASURES

Wall

Internal or external insulation to no-fines, large panels and some cavity walls.

Cavity fill where appropriate or external insulation where concrete frames create thermal bridges.

Windows

Provide new double glazed high performance windows and frames or as a minimum draughtstrip existing windows.

Doors

Provide new entry doors to flats and doors to balconies or draughtstrip existing doors.

Balconies and common access ways

Consider total enclosure of these areas.

Roofs

Add insulation to the existing roof to achieve at least minimum Building Regulations standard.

Ventilation

Provide controllable ventilation including extract fans to kitchens and bathrooms.

Heating

Provide efficient heating systems with effective easy to use controls.

Consider background heating to common entrance and stair areas.

Energy advice

Involve tenants in upgrading decisions and provide energy advice for effective use of the heating system after upgrading.

HOW TO SELECT ENERGY EFFICIENT MEASURES

The best way forward is to develop an affordable warmth programme that provides answers to the following questions:

- What can tenants afford to spend on fuel?
- What target should be set on heating costs?
- How far does the stock fall short of the set target?
- How to select energy consumption targets which can be met by energy efficient measures.

INVOLVING AND ADVISING TENANTS

Tenants should be consulted before refurbishment either in the tenant/landlord relationship or as important participants in a community action programme. It will be necessary to illustrate at that consultative stage the imperative need to upgrade the energy efficiency of the dwellings:

- to improve comfort standards
- to reduce annual running costs
- to maintain the dwelling in good condition
- to contribute to safeguarding the global environment.

Wherever possible, the aim should be to achieve a complete package of energy measures, since partial upgrading can often lead to problems elsewhere (eg condensation forming on cold bedroom walls due to the installation of well-sealed, double glazed windows with no other thermal or heating upgrading).

As there will be priorities to be selected from competing demands on limited budgets, these issues must be presented in a way that is easy to understand.

Tenants should be fully informed about the improvement options: the capital costs involved and the benefits that will ensue. It should also be made clear how the capital costs will be met. Understanding and agreement is likely to be easier when tenants are properly informed and have assisted in the selection of priorities.

A full energy upgrading package will have to be explained in detail to tenants not only immediately after completion but also in follow-up visits, covering:

- the control of the heating system
- the setting of thermostats and/or radiator valves
- the control of ventilation – mechanical in kitchens and bathrooms and trickle vents in other rooms
- the action to take when washing and drying clothes.

Tenants must be assisted in understanding how to deal with the ventilation of their dwelling and the most economic and effective way to control their new heating system. This is particularly important for hard-pressed parents of large low income families, and for the elderly and the disabled. If the system is too difficult to understand, they may either incur fuel bills beyond their ability to pay or they may not use it at all and the dwelling will return to being cold and damp. If tenants know how to operate the heating and ventilating systems properly they will gain substantial benefits in comfort and costs.

Type of household	As % of all council tenants	Average weekly spending	Spending on fuel, light and power	Fuel, light and power as % of income
Single person families:				
Pensioners	22	£64.80	£8.38	13
Non-pensioners	7	£77.53	£7.47	10
Other families without children:				
Pensioners	11	£134.48	£10.78	8
Non-pensioners	6	£192.75	£11.38	7
Families with children:				
Single parent and child	6	£90.30	£10.63	12
Single parent with children	5	£138.34	£13.30	10
Two parents with children	5	£205.53	£13.56	7
Note. The above figures are not just for heating alone. They are for expenditure on all fuel, light and power in the home.				

Table 1 Average weekly spending on fuel, light and power by low income council tenants (from 1991 Family Expenditure Survey)

Dwelling size	Target costs for heating £/week	£/year
Bedsitters and 1 bedroom	2.80	145
2 bedroom	4.10	210
3 bedroom	6.10	235
These targets are indicative only and may not always be achieved in practice.		

Table 2 Target costs for heating

WHAT CAN TENANTS AFFORD?

Family Expenditure Survey figures for expenditure on fuel, light and power for households on low incomes in 1991 are given in table 1. The last column shows expenditure on fuel, light and power as a percentage of total income. The figures show that the lower a household's income, the higher the proportion spent on fuel. The national average is about 6%. The Family Expenditure Survey does not identify expenditure on heating separately from other uses of fuel. There are a number of sources which may be used to estimate the proportion of expenditure which goes on heating, including a very detailed study in Birmingham in the early 1980s – the Energy Improvement Kit (EIK) project. The breakdown between the different uses in that study is given in figure 1.

SETTING A TARGET FOR IMPROVEMENT

It is suggested that reasonable target costs for heating might be those set out in table 2.

As can be seen from figure 1, if standing charges are subtracted from the total spending on fuel, light and power, typically about half the remaining expenditure is on heating.

The targets in table 2, however, assume that space heating expenditure is slightly less than half, in fact between 40% and 45% of the total which allows for some variations between households. The target is set lower than the 50% average to ensure that even the low spending families can obtain affordable warmth.

For one-bedroom accommodation the target cost for heating has been based on fuel expenditure by single pensioners. Similarly fuel expenditure by a single parent and child has been used for the 2-bedroom target, and expenditure by single parent with more than one child for the 3-bedroom target.

Figure 1 shows spending on fuel, light and power by seven, low-income, two-person households. (Source – the Birmingham EIK study – 1990 prices.)

HOW DOES YOUR STOCK FALL SHORT OF THE TARGET?

Having set running cost targets, what improvements are needed to the insulation and heating standards of the high rise dwellings in your stock to enable your tenants to achieve

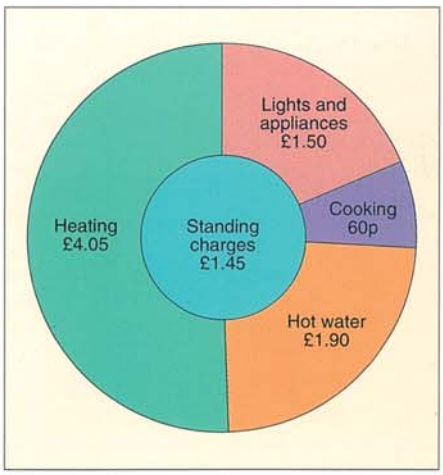


Figure 1 Fuel, light and power expenditure

full comfort conditions when their expenditure on heating is limited to these amounts?

It is a two-stage process. First, it is necessary to carry out an energy survey of the stock which will establish the heat loss and heating system performance of typical dwellings. It is then possible to explore options for cost-effective improvements to insulation and heating to bring dwellings up to the standard necessary to meet the target running costs.

Both stages can be carried out using BREDEM-based software. Energy rating schemes based upon BREDEM now incorporate the Government's Standard Assessment Procedure (SAP) see page 6.

THE STOCK SURVEY

The following information needs to be collected to calculate heat losses and heating system performance and to create a computer stock model that can be rapidly adjusted to evaluate various energy options:

- the materials and type of construction of walls, floors, windows, doors and other external elements
- the presence of any insulating measures, eg roof insulation draughtstripping, double glazing
- the areas of walls, windows, roofs, etc
- the existing heating and hot water systems, and whether each dwelling has a gas supply or an off peak electricity meter.

DEVELOPING AN AFFORDABLE WARMTH PROGRAMME

It is important that when energy efficient measures are undertaken in modernisation or refurbishment works, decisions about financial priorities, standards, design and detail are made to a co-ordinated policy based on 'affordable warmth' targets. Different people in various departments within the Local Authority will act with reference to different criteria. It is, therefore, imperative that for their combined actions to be effective and efficient, the policy is clear and practical and covers all relevant aspects. Opportunities for improving energy efficiency should be identified and built into the general strategy for all work to be implemented when finance is available.

The best opportunity for energy upgrading occurs when full conversion work takes place, but energy measures should also be considered when repair or replacement is necessary or where other alterations necessitate changes to existing structures or finishes (see table 3). For example, if extensive repairs are required to the external face of a high-rise block, it can become more cost effective to provide external insulation as part of an upgraded finish. The opportunity should always be taken (in both cost and simplification of installation) to combine appropriate measures and activities.

A primary objective in all work must be to insulate the fabric of the dwelling. It may be beyond the tenant's ability to pay the annual fuel costs of a new central heating system in an uninsulated flat, even if there is a greater comfort benefit obtained.

GENERAL IMPROVEMENTS	POTENTIAL FOR ENERGY UPGRADING
Rewiring	Internal wall insulation
Refitting kitchens and bathrooms	Internal wall insulation. Double glazing
Repairing spalling concrete	External insulation
Upgrading external environment	External insulation
Repairing windows (replacing windows)	Draughtstripping. Double glazing. Reduce glazed area
Repairing heating system	More efficient or lower tariff system. Smaller system for insulated dwelling
Repairing cladding	External insulation
Repairing flat roof	Add insulation
Repairing doors to balconies	Insulate doors

FINDING THE MONEY

Below are three suggestions. They are not mutually exclusive; an Authority could adopt all three as appropriate.

Increase rent to pay for extra insulation work

This approach must be financially viable for the tenant. Any rent increase attributable to the insulation work should be less than the anticipated savings in the heating bill. When evaluating anticipated savings, it should be borne in mind that tenants with the lowest energy bills tend to take a larger part of improvements to energy efficiency in the form of increased temperatures rather than reduced energy bills.

Provided this is taken into account, a rent increase is an obvious possible solution, particularly when insulation is included as part of an overall improvement package which could imply a rent increase anyway.

Install a cheaper heating system to offset the cost of insulation

Some councils are switching from full gas central heating systems to a 'modular' approach consisting of unit heaters combined with an insulation package.

The insulation package reduces heat loss to a level at which individual heaters can provide the same design level of comfort (21°C in living rooms, 18°C elsewhere) as a standard gas system of boiler and radiators, but for lower capital cost and with lower running costs. This allows more properties to be upgraded within a set budget. What is more, tenants have been found to prefer the familiarity of the simpler controls on unit heaters to central heating programmes and room thermostats.

Offset capital costs of insulation against future savings in revenue

This approach is mainly applicable to housing that has become 'run down' and/or presents serious and expensive on-going maintenance problems.

The DOE's Estate Action programme includes over 100 examples of 'Affordable Heat' schemes where heating and insulation packages have formed an essential part of programmes to revitalise run-down estates.

SETTING PRIORITIES

These priorities might include the following.

- Establishing a proportion of the maintenance/capital repairs budget to be set aside for initiating an energy improvement programme. A programme to bring all properties up to a set standard could be planned over a 10-year period and costed on an annual basis.
- Targeting the homes in greatest need, for example those with the highest heat loss, inadequate heating or expensive to use heating systems such as ceiling heating.
- Reviewing improvement and renovation practice as well as repair and maintenance work in the light of the heat loss targets and upgrading the specifications as necessary.
- Reviewing window replacement programmes. This might mean taking a decision that all replacement windows and doors should have good quality draughtstrippng and be double glazed, and that all windows should be provided with trickle ventilation in accordance with the requirements of the 1990 Building Regulations
- Establishing links with organisations such as Neighbourhood Energy Action that can provide effective advice to tenants.

As budgets get tighter and financial constraints more rigid, it becomes increasingly important to involve tenants in budgeting decisions. Meaningful consultation would involve offering tenants an agreed menu of options. Ideally they would also have information about the fuel costs savings likely to result from each measure. This will help them decide which options they can afford, as well as those which will benefit them most. Some local authorities try to give individual flexibility, but for major improvements it may be necessary to gain a consensus from all the tenants affected.

PRESENTING AND ANALYSING THE RESULTS OF THE SURVEY

The information from the energy survey should be presented in a way that makes it possible to see quickly which blocks need to be upgraded to meet the set target.

SELECTING APPROPRIATE IMPROVEMENTS TO INSULATION, HEATING AND VENTILATION

Some software incorporating BREDEM allows the user to put in his own cost information for different types of insulation and heating systems and so evaluate the most cost effective way of meeting the target. Some also allow a simple assessment of the condensation risk.

A full package of energy saving measures will produce the best result:

- add insulation to the roof
- insulate external walls with external or internal wall insulation, or cavity fill if appropriate
- provide new double glazed high performance windows
- provide new draughtstripped external doors to flats
- provide new draughtstripped common entrance doors
- enclose balconies or common access ways
- consider background heating to common entrance stair areas
- provide controlled ventilation including extract fans.

Where there are physical or cost constraints, particularly with regard to wall insulation, partial measures may be necessary. If carefully selected, worthwhile savings can be achieved. The risk of condensation should always be assessed. Draughtstripping windows and doors increases the heating standard of the dwelling but can also create conditions for condensation.

MEASURES TO CONSIDER

The following are brief descriptions of energy saving measures available for the various parts of the building. Costs of measures vary considerably because of the variations in height, complexity and ease of access of high rise blocks. The costs (at 1990 prices) are for guide purposes and are based on an average two bedroom flat.

WALL INSULATION

External insulated cladding (over-cladding)

- High cost.
- Suitable for solid walls and brick cavity walls but a careful assessment of adequacy of fixings required for concrete walls and fire regulations should be checked.
- Structural repairs must be carried out before over-cladding.
- Can save up to 25% energy annually.
- Can improve appearance of blocks.
- Can effectively reduce thermal bridging.
- Can improve weather resistance of wall.
- COST: approximately from £3500 per dwelling for rendered external insulation to £18 000 per dwelling for a sheet overcladding system.

Internal lining

- Moderately expensive .
- Can normally be used with all construction types.
- Reduces room size slightly.
- Will not improve weather resistance of walls.
- Difficult to deal effectively with thermal bridging in some high rise blocks.
- Can save up to 20% energy annually.
- COST: approximately £1700.

Cavity fill

- Low to moderately expensive.
- Suitable for buildings above 25 m only after special assessment.
- Use restricted because of extreme exposure of high blocks.
- Where external skin is rebuilt, partial cavity fill may be appropriate.
- Stabilising cavity foam may be considered where panels need stabilising, eg insufficient or corroded ties.
- System must have a BBA certificate and installation carried out by approved contractor.
- Depending on width of cavity, can save up to 20% energy annually.
- COST: approximately £450.

ROOF INSULATION

Adding insulation on top of existing structure.

- Cost-effective when roof is being recovered or extensively repaired for weather proofing.
- Will require periodic maintenance.
- Can save up to 20% energy annually for top floor flats.
- COST: approximately £300 per flat spread over whole block.

Constructing pitched roof over existing flat roof

- High cost.
- Easy to include insulation.
- Can make a dramatic change to the appearance of blocks.
- Structure must be checked for suitability.
- Can save up to 20% energy annually for top floor flats.
- COST: approximately £700 per flat spread over whole block.

FLOOR/BALCONY INSULATION

Insulation to soffits of exposed floors to flats, balconies and galleries.

Over slab insulation to balcony or gallery floors:

- is moderately expensive
- should link up with wall insulation to reduce thermal bridging and condensation problems.

WINDOWS

Replacement windows

- Often the best option but high cost.
- Can improve or change appearance.
- When window replacement is necessary, double glazing is a cost effective method compared with single glazing.
- Replacement units can incorporate panels to reduce large glazed areas.
- Reduce cold draughts.
- Provide 'trickle' ventilation.
- Depending on size of window, can save up to 12% energy annually.
- COST: approximately £2500.

Secondary glazing

- A separately glazed single frame fixed internally when it is difficult to replace existing windows.
- Can have similar attributes to double glazing.
- COST: approximately £1000.

Draughtstripping existing windows

- Least cost but difficult to be totally effective with extreme exposure of high flats.
- Frames must be in good condition.
- Adequate ventilation must be achieved after fitting.
- COST: approximately £110.

EXTERNAL DOORS AND COMMON ENTRANCES

- Replacement doors or draughtstripping improves comfort standard.
- Replacement doors and creation of porch or vestibule to common entrances are cost effective when included in security access improvements.
- Landlord controlled background heating for common areas reduces heat loss from flats.

CONTROLLING VENTILATION

- Repair or replace mechanical stack ventilation systems for internal bathrooms.
- Provide humidistat controlled extract fans in kitchens.
- Specify replacement windows with 'trickle' ventilators.

SPACE HEATING AND HOT WATER SYSTEMS

- Improved heating without good insulation will not save energy and will be costly for tenants.
- In a well insulated flat a new heating system can be scaled down to give comfort standards at affordable costs.
- System should be appropriate to occupancy; elderly, housebound people need a different system to young working couples out all day.
- The economic provision of hot water should be considered as part of the overall heating system design.
- Controls must be easy to understand and use.
- Hot water cylinders and pipes must be lagged.

WHO TO CONTACT

- COST: approx. Electrical £1000 - 1500
  Wet system £2000 - 3000
- Consider heating the block from one central boiler as an alternative to individual boilers in flats.
- Consider combined heat and power generators (CHP) as these system can be very energy efficient.
- Consider electrical 'heat with rent' schemes.

CONDENSATION AND ENERGY EFFICIENCY

The energy saving measures described above will reduce condensation risk, particularly if a full package of measures is undertaken, but it is critically important that the dwelling is properly ventilated.

Draughtstripping windows and doors increases the heating standards of the dwelling, but can also stop the warm moist air escaping and can create conditions for condensation.

Therefore ensure that:

- trickle ventilators are included in new draughtstripped windows
- humidistat controlled extract fans are provided in kitchens and bathrooms
- door closers are fitted to kitchen and bathroom doors
- the tenants know how to use the heating system and understand the importance of ventilation.

WHO TO CONTACT FOR FURTHER ADVICE

TECHNICAL SERVICES DEPARTMENT OF THE LOCAL AUTHORITY for:

- condition of work
- feasibility studies
- previous upgrading measures.

BRECSU for:

- EEO Best Practice programme publication on energy efficiency in all buildings.

  Enquiries Bureau
  BRECSU
  Garston
  Watford WD2 7JR
  Tel: 01923 664258

- Energy Design Advice Scheme (EDAS) Regional Office

Scotland	Tel: 0131 228 4414
London	Tel: 0171 916 3891
Northern Ireland	Tel: 01232 364090
Sheffield	Tel: 0114 272 1140

LOCAL ARCHITECTURAL OR TECHNICAL CONSULTANCIES for:

- feasibility studies
- costing and implementation.

ENERGY EFFICIENCY OFFICE for:

- general advice on energy efficiency
- sources of further information.

BUILDING RESEARCH ESTABLISHMENT for:

- current advice available on consultancy basis
- special studies of projects
- assessment of energy saving and condensation risks.

  Bucknalls Lane
  Garston
  Watford WD2 7JR
  Tel: 01923 664664. or,

  Scottish Laboratory
  Kelvin Road
  East Kilbride G75 ORZ
  Tel: 013552 33001

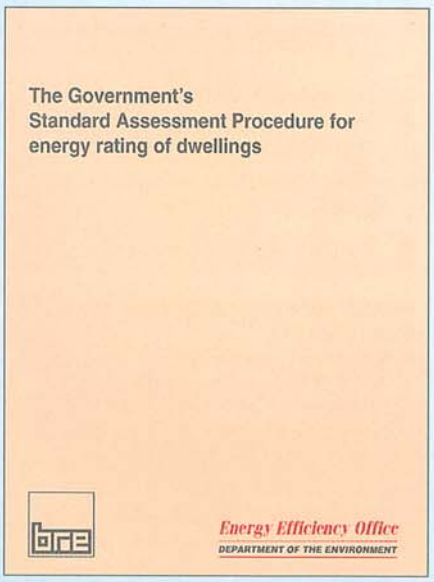
LOCAL ENERGY PROJECTS, for:

- advice and installation of a range of energy measures
- energy audits.

  Neighbourhood Energy Action
  2/4 Bigg Market
  Newcastle-upon-Tyne NE1 1UW
  Tel: 091 261 15677

Home Energy Rating

An energy rating for a dwelling provides a simple expression of its energy efficiency. The rating provides a means of comparing dwellings singly or in groups. The same dwelling or dwellings can be compared before and after improvements. In particular, the use of energy ratings should enable decision makers to take energy efficiency into account on a rational basis when designing new dwellings or refurbishing existing ones. For building professionals, ratings can be used as a design tool to optimise energy efficient design.



The Government's Standard Assessment Procedure (SAP)

In July 1993, the Government published its 'Standard Assessment Procedure'. The SAP is the Government's standard system for home energy rating. Developed by the Building Research Establishment in discussion with other energy rating professionals, SAP is based on the BRE's domestic energy model (BREDEM). It provides a simple means of reliably estimating the energy efficiency performance of dwellings. SAP ratings are expressed on a scale of 1 to 100. – the higher the number the better the rating. As from July 1995, all new dwellings (including conversions) in England and Wales will have to have a SAP rating to comply with the Building Regulations. (The Building Regulations covering Scotland are under review and those for Northern Ireland will be reviewed in due course.)

How to obtain a SAP rating

The SAP publication provides the methodology from which SAP ratings can be derived using reliable data for the dwelling. In addition, a number of home energy rating organisations provide SAP ratings.

REFERENCES

1 **Anderson B R,** *Energy assessment for dwellings using BREDEM worksheets, BRE Infomation Paper IP 13/88,* BRE Watford, 1988.

2 **Anderson B R, AJ Clarke, R Baldwin and N O Milbank,** *BREDEM The BRE Domestic Energy Model – background, philosophy and description.* BRE Report: BR 66, BRE, Watford, 1985.

3 **Henderson G,** *Estimating energy costs and potential savings in housing, BRE Information Leaflet 6:* BRE Watford, October 1988 (updated March 1991).

4 **Anderson B R,** *British Standard Code of Practice for energy efficient refurbishment of housing,* BRE Information Leaflet 7: BRE Watford, October 1988 (updated February 1991).

5 **Anderson B R,** *Energy assessment for dwellings using BREDEM worksheets,* BRE Information Leaflet 8: BRE, Watford, October 1988 (updated February 1991).

Note: The costs shown on page 5 have been assessed from a sample cross section of contract cost information for modernisation or rehabilitation works incorporating the insulation measures and forms of heating installation described. The individual costs have been adjusted to arrive at a mean for the UK as a whole and therefore, must be used for guidance only. Cost of energy efficiency measures carried out in association with other work could be significantly lower.

Energy Efficiency Best Practice in Housing

Tel: 0845 120 7799
www.est.org.uk/bestpractice

Energy Efficiency Best Practice in Housing is managed by the Energy Saving Trust on behalf of the Government. The technical information was produced by BRE.